APPENDIX J

Present Value Analysis for Selecting a Communication Medium for a Traffic-Signal Control System in Richardson, Texas

Due to rapidly evolving technology in the telecommunications industry, many alternatives exist for a communications sub-system for traffic signal control. Traffic signal systems have a 10-12 year life due to an accelerated depreciation in a harsh operating environment and rapid advances in technology.

The City of Richardson is currently upgrading the traffic signal and video systems using $1,075,000 in federal ISTEA funds, $550,000 in local bond funds and $375,000 in area DART funds. The communications link is critical to the success of these projects and involves a certain amount of risk due to the deregulation of the cable / telephone monopolies, FCC regulations, and the possibility of equipment suppliers becoming insolvent. Moreover, the choice of the communications medium can vary total system costs by 75% over the life of the equipment. Therefore, a present value cost analysis of the communication alternatives is needed to allow management to choose a communications medium for the project and to perform sensitivity analysis of the assumptions used to drive the cost models. Only the traffic signal communication sub-system is evaluated in this preliminary study which looks at alternatives to the existing CATV communication system.

The following alternatives are compared based on an initial capital investment and the net present value of maintenance costs and service fees projected over a 10 year life. The cash flows for these alternates are presented at the end of this report and are summarized as follows:

ALTERNATE A - DO NOTHING

This alternate considers the cost of purchasing 28 additional Sonex modems to expand the signal system and provide equipment spares, and 25 additional modems to replace failures expected over the 10 year period. All anticipated replacement costs are assigned to year 0, because price quotes from Sonex for the modem currently used by the City of Richardson range from $ 8,700 per unit in quantities of 1-5, to $ 2,900 per unit in quantities of 26-up. This compares with a single unit price of $ 1,800 for the new Sonex modem which the manufacturer claims is superior in terms of cost and technology to the original modems purchased in 1985. Upgraded modems cannot be combined with old modems in the same system because of design constraints in the CATV system. Therefore, the City must choose between a do- nothing (upgrade existing modems) and Alternative B - upgrade all CATV modems.

ALTERNATE B - UPGRADE CATV MODEMS

This alternate quantifies all costs to upgrade Sonex modems at 92 existing intersections and purchase 28 additional modems to expand the system and provide equipment spares. The modem failure rate for new modems is estimated at 1 unit per year and these costs are spread over the 10-year design life (2.5 failures per year in Alternate A were all assigned to year 0 due to pricing). The modem repair rate for new modems ranges from zero at year zero increasing by 0.5 units/year over the 10 year life. This compares with a current repair rate of 2 modems per year for modems purchased in 1985. These rates are based on current maintenance data and are accelerated for the older modems in Alternate A due to age of the equipment. Both Alternate A and B consider costs for CATV test equipment and additional equipment (translators) needed at the TeleCable head-in.

Even though Alternate B has a net present value cost of $ 21,405 more than Alternate A, this alternate is preferred because neither alternates takes into account the additional maintenance costs and the reduced quality of service expected from the current CATV modems purchased in 1985.

ALTERNATE C - TELEPHONE LAN LINES AND MODEMS

City staff met with representatives from Southwestern Bell on May 2 and 9 to discuss the costs and rates. The equivalent telephone sub- system needed to replace Richardson's existing CATV communication system calls for 220 2-wire 19.2 kbit multi-drop phone (110 4-wire) circuits at $43/month/circuit. A telephone based alternate cannot compete with a CATV alternate which has no monthly fees. Southwestern Bell also provided a second alternate (Alternate G) for LAD lines (see below) which is a better alternative using telephone for data communications.

ALTERNATE D - CELLULAR TELEPHONE MODEMS (CALL ON DEMAND)

This alternate compares costs for a signal system using cellular technology with "call on demand" rather than a "polled response" architecture. Alternates A - C above call for a central computer to initiate a "polled response" from all intersection controllers at least once per minute. Since polled systems require a continuous connection, cellular technology is not feasible at current rates. Therefore, Alternate D develops costs based on actual usage (see attached time usage estimates provided by City operators).

Additional controller software would be required to implement this "call on demand"approach because the local controller would be responsible for initiating calls when alarm conditions occur rather than detecting alarms through a "polled response" method. A "call on demand" system is feasible and could emulate Richardson's current system at a more attractive cost than Alternate C (leased LAN lines).

Richardson's current system returns very little data with each polled response (less 1 byte of information per minute per intersection). However, Richardson's next generation signal system is expected to return additional status flags, detector data and measures of effectiveness (10-16 bytes per minute) enabling system operators to detect incidents and monitor system operation. This additional data warrants "polled response" and the additional data overhead is not reflected in the connect times developed for alternate D. Alternate E considers a modified cellular option from Ram Mobile Data which is based on the amount of data actually passed through the system rather than connect time rates used with cellular telephone modems.

ALTERNATE E - MOBILE DATA NETWORKS

RAM Mobile Data (Norcross, Georgia, (404) 662-1740) is a venture between RAM Broadcasting and BellSouth which provides modems and a wireless data services for mobile data markets, remote data collection terminals, inventory control and E-mail. These systems require continuous on-line access to remote computer systems so RAM costs the service on actual data transfers rather than

connect time. The costs for Alternate E from RAM Mobile Data are applied to the data transfers expected per intersection for Richardson's proposed "polled response" system. Note that the data rates exceed the maximum monthly usage charged by RAM. This system is too costly and relies on a sole source provider and specialized modem equipment that increases risk over the 10-year design period.

ALTERNATE F - SPREAD SPECTRUM RADIO

Spread spectrum radio was developed during World War II to resist enemy surveillance and jamming. In 1985 the Federal Communications Commission opened up the 902/928, 2400/2483.5 and 575/5850 Mhz regions to spread spectrum. The advantage of this wireless alternative is that special licensing from FCC is not required, the system works well in noisy environments, and no cable costs or monthly fees are required. Base stations are required and have a range of 0.5 to 6 miles depending on height of the receiving station. Power is limited to 1 watt (effective radiated power of 4 watts); however, total coverage for the City of Richardson could be achieved with base stations at building locations accessed for video surveillance.

Because this is a new technology, many FCC regulations are in a state of flux, making spread spectrum a high risk alternative over the 10-year design life. Moreover, spread spectrum frequencies are not controlled, increasing the risk from interfering stations and product obsolescence when FCC regulations redefine the technology. Extreme care should be exercised to insure that the initial investment made for this technology can be fully utilized throughout the design life of the equipment. The costs of spread spectrum for traffic control were obtained from Transyt Corporation, a NEMA traffic signal manufacturer in Tallahassee, Florida.

ALTERNATE G - TELEPHONE LAD LINES AND MODEMS

Southwestern Bell provided preliminary estimates for LAD (local area data) line. These rates are tariffed if the data lines pass through a CO (central office facility) of Southwestern Bell. Since a CO is conveniently centrally located in Richardson, (Belt Line Road at Greenville), this alternative deserves further consideration and a final estimate is being prepared by Southwestern Bell. LAD lines are certainly cheaper than LAN lines (Alternate C); however, data concentrators must be provided to limit line distances to less than 2 miles and data transfer rates are considerably lower than LAN alternatives (19.2 kbit or less). The majority of signal systems in the country are based on leased telephone lines using on-street masters. Traffic signal on-street masters can be used at the data concentrator with LAD lines to provide a more economical alternative than LAN lines.

ADDITIONAL DESIGN CONSIDERATIONS

1.) Benefits of the Existing CATV Communication Sub-System -The City of Richardson has received excellent service and reliability from the CATV system installed in 1985. It is doubtful, that any of the above mentioned alternatives can improve service significantly, since the system design is distributed and quite forgiving, allowing for temporary breaks in communication without affecting the operation

and timing of the traffic signals. System communications provide upload/download capability and maintain the accuracy of the time clocks in the local units used for system coordination.

Specifications for new CATV modems are currently being written and staff hopes to increase data transfers from 9600 to 19,200 baud. This additional throughput will be used to improve system monitoring and report measures of effectiveness from the intersections for detection of incidents and signal timing optimization.

2.) Building Redundancy into the Communications Sub-System -The major reason for upgrading Richardson's current system is to obtain a source of new equipment, since IIM Minnesota Microtronics, the manufacturer of Richardson's current signal controller went out of business 4 years ago. In addition, the replacement cost of Sonex modems has risen from $ 1800 to $ 8700 per unit (in quantities less than 5 modems).

Richardson's current system must be totally replaced because the City's franchise agreement limits communications to one data link (forward and return frequency), and this link cannot be shared between old and new equipment. The proposed upgrade project will improve equipment availability; however, redundancy should be designed into the new system to minimize risk. Otherwise, 5 years into the service life of the new system, the City could find itself in the same position without a source of controller equipment and faced with no alternative than to replace all system equipment at one time.

The current 1985 Sonex modems utilize 1 MHz bandwidth in a 3 MHz region reserved for traffic control to achieve a 56.2 kbit baud rate over the CATV network (however, throughput is limited by the rate of the controller at 9600 baud). The proposed utilization of the 3 MHz bandwidth calls for 4 - 500 kHz signals at 19.2 kbits providing a maximum 64 intersection addresses per frequency pair. This design is based on information provided from Sonex. Tytec claims to be able to provide over a dozen frequencies within this 3 MHz bandwidth at the design baud rate. These issues are being reviewed by Richardson's communications consultant and will be resolved within the specifications and test procedures developed for the modems.

These proposed frequency allocations within the existing 3 MHz bandwidth provide redundancy in the communications sub-system. Suppose a "Brand X" intersection controller is selected to replace the IIM controllers in 1995, and "Brand X" becomes insolvent before the end of the 10-year service life. A replacement controller ("Brand Y") can be sourced that operates as a separate system on a separate frequency pair from "Brand X" (see Figure 2.). This redundancy also applies to alternate sources for CATV modems and precludes the current situation of having to replace all modems and controllers because a manufacturer went out of business. Moreover, this design consideration protects the City against price gouging such as the present replacement cost for existing Sonex modems ($ 8,700 / each in quantities less than 5). Multiple frequencies would allow the City to adapt several modems within the same system.

CONCLUSIONS AND RECOMMENDATIONS

A summary of the net present value of these alternatives is provided below:

Alternative for a Communication Medium	Total NPV	City's NPV Cost (after ISTEA participation)
A Do Nothing - Existing Sonex modems on CATV	$ 225,091	$ 91,226
B Upgrade CATV Modems	$ 252,496	$155,289
C Telephone LAN Lines (1 Minute Poll)	$ 995,189	$ 754,065
D Cellular Telephone (Call on Demand)	$ 474,057	$ 316,267
E Ram Mobile Radio Modem (5 Minute Poll)	$ 1,437,391	$ 1,101,048
F Spread Spectrum (1 Minute Poll)	$ 425,602	$ 107,087
G Telephone LAD Lines (1 Second Poll)	$ 441,882	$ 268,475

* NOTE: Federal ISTEA funds can only be applied during the first two years of the project. The City's actual cost was calculated based on a 20% match during the first two years (combined with 80% ISTEA) and 100% for years 3-10.

The lowest cost alternative for a communications sub-system based on total net present value and the City's actual cost with federal ISTEA participation is Alternate B - Upgrade CATV modems (using price quotes from Tytec). The excellent quality and service provided by TeleCable since 1985 is expected to continue when the City of Richardson and TeleCable renew their franchise agreement in 1995. Cellular communications can provide an excellent back-up system when CATV communications are disrupted, and the City is looking into 10 mobile communication links for a backup to the CATV system. CATV should continue to be an attractive medium for "polled response" signal systems because of the increasing interest in 2-way data communications (information highway), pay-on-demand television, and the current merger of cable and telecommunication technologies.

The City of Richardson should request continued use of the current 3 MHz forward and return bandwidths used for traffic signal control from Telecable Inc. Exact frequencies within the current 3 MHz bandwidths will be determined only after a modem is selected for Richardson's signal system upgrade. Therefore, the City should insure that the current bandwidths used for traffic signal communications are available at no cost to the City of Richardson when the franchise agreement with TeleCable is renewed in 1995.

Adapted from John Black, May 2, 1994 (www.startel.net/atms/COMCOST.HTM)

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